ECE 403

Options Considered

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Kayla Helseth

Mark Jund

Justin Sipma

Nate McBeth

Introduction

The equatorial stargazing platform will be a device which will remain stationary relative to the stars, moon or sun. In order for an astronomer to take a picture of a celestial body, the exposure time must be a few minutes. In this time, the movement of the Earth causes a phenomenon known as “star trails”. This platform will allow an extended exposure time without star trails by adjusting the telescope to track the stars in accordance with the Earth’s rotation. The user will be able to choose if they want to track the sun, moon or a star and will simply press a button to start the platform.

Previous Work

Barn-Door Equatorial Platform

One of the first products that came up was an equatorial platform designed for Dobsonian Telescopes. How this platform works is by use of its three curved feet attached to a top plate. These curved feet allow the top plate to rock equatorial through a 20 degree arc. Going through the full motion of this platform allows for 80 minutes of uninterrupted viewing time.

Below the mounting plate lies the bottom support plate which rests firmly on the ground during operation. Attached to it are two north roller bearings and three south bearings which allow the top plate to move in its equatorial motion.

The platform itself is then operated by a motor which controls the tracking motion and causes the top platform to move in its equatorial motion.

Barn-Door Equatorial Platform

The two pictures just pictured above are courtesy of Equatorial Platforms out of Grass Valley, CA. The first picture shown is the platform at 10 degrees east before the start of its motion. The second picture then corresponds to the platform 80 minutes later at 10 degrees west. So you can see how the platform moves in its equatorial path during its time in operation. Even when operating, the observer can change

what they are viewing without making any adjustments to the platform. Finally, the platform can be reset with a simple pull of a handle located on the bottom plate.

This platform is designed to work at any “nominal” latitude but can be adjusted to work at any latitude just by making a few adjustments. Equatorial Platform can custom design any platform to accommodate any size, type, and make of Dobsonian Telescope. These platforms can be priced as cheap as $1,350 for a 6 inch telescope up to $4,250 for a 32 inch telescope, not including any additional accessories.

Equatorial Platform

Our design group is continuing the work done by a past group and their project. In their efforts to create an equatorial platform, they took a different approach than the platform example shown above. Their equatorial platform starts with a top circular platform where the telescope would be mounted. This circular platform moves approximately ±6.5 degrees from its normal resting position for a total of 13 degrees of rotation. This is done by the use of a smaller stepper motor that acts to spin the stage in its circular motion.

Below this platform lays a second platform attached by a hinge that controls the west to east motion of the platform. A simple stepper motor will raise and lower one end of the second platform to control the entire platform’s east to west motion.

The third platform works to control the north to south motion. Just like before, a stepper motor lowers and raises the third platform so that it can pivot from north to south. This platform is attached by a hinge to the entire unit so that it can function as one, smooth operating system.

Equatorial Platform

The picture shown above is of the equatorial platform completed by a previous design group. As mentioned, the circular disc rotates approximately 13 degrees and the two platforms beneath it adjust the north to south directions and the west to east direction. The last platform acts as a resting base for the entire unit.

The three stepper motors are operated by a PIC board. The user first levels the platform and then adjusts the base to the celestial body they are going to observe. After that, “enter” is pressed and the PIC board works to adjust all three stepper motors so that the entire platform moves in one fluid equatorial motion.

Design Options and Selected Approach

Adjusting the Platform’s Tilt

When we first looked at last year’s equatorial platform there were a lot of good things about their design as well as a few flaws. One of the decisions our group liked was how they got their platform to adjust from north to south and west to east. They used one stepper motor to control the north to south tilt of the platform and another stepper motor to run the west to east incline. We soon learned that these motors were rated for 700 pounds of force each and being that the telescope’s center of gravity was located right in the middle of the platform, it made such bulky stepper motors unnecessary. One of our requirements was to minimize power consumption and this would be a great place to start. We performed some research and we found a different line of stepper motors rated for 57 pounds each that Professor Glower thinks will work.

Use Heavy Duty Stepper Motor

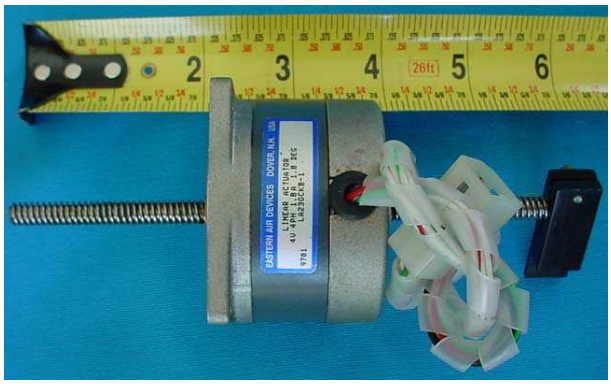
Advantages:

- Proven to work for our type of design
- Can withstand Obsession 18” telescope plus more

Disadvantages:

- Consumes too much power
- Unnecessary for a 150 pound load
- More expensive unit to purchase

Use Stepper Motor Driven Linear Actuators



Advantages:

- Consumes less power
- Screw would be able to travel 4.5” which is plenty of room
- Cheaper than Heavy Duty Stepper Motor

Disadvantages:

- Withstand only 57 pounds
- Slow operating time

Rotational Operating Stage

We think we can improve over the last concept platform in this design by creating a rotating stage that could turn 360 degrees if necessary. The design group before us made a concept that would work for its purposes but when at a different latitude it would be nice to adjust the direction in which the telescope is looking by use of a fully rotating stage. Once we made this decision we first thought that a stepper motor could turn a small gear that would be attached to another gear fastened to plate. This plate would then turn with accordance to the stepper motor. The other idea brought up was to eliminate the gears and use a belt instead. This belt would be attached to a stepper motor as well as the stage to allow for a 360 degree rotation.

Use Gears for Rotational Purpose:

Advantages:

- Long lasting design option
- Simple design to implement

Disadvantages:

- More expensive route
- Binding of gears could be a problem

Use a Belt for Rotational Purposes:

Advantages:

- Less equipment that could fail
- Cheaper route to take

- Less weight forced on the stepper motors

Disadvantages:

- Not as durable as a metal gear

Microcontroller

The microcontroller that we decided to use was the PIC 18F4620 because it has all of the capabilities needed for our project. It has enough I/O ports and processing speed to control the stepper motors. It is also the same microcontroller that we used in our ECE 376 class so we are familiar with its operation. The PIC will be used to control three separate stepper motors and will use Interrupts for timing.

Advantages

- Familiarity to PIC from previous class
- Low cost
- Low Power
- Proven to Work
- Same controller as previous project

Disadvantages

- Not enough I/O ports if we would want to significantly expand our design
- Not enough memory if we would expand our source code to have extra features

Platform Hinge

When we started this project we decided that we wanted to improve the design from the past year. We wanted to get rid of the dual hinge design that needed three layers from the past design and wanted to use just two layers. We decided that the best option would be to use some type of joint directly in the center of the two layers that would be able to pivot on the two axes. We considered using some form of large ball bearing sandwiched between two pieces of plywood with that would be held in place by just cutouts in the wood. We also considered using a universal joint similar to those on the driveshaft of a car, but the idea that we decided would be the best was using a ball joint hinge.

Using a ball sandwiched between the plywood

Advantages

- Ease of assembly
- Load bearing capabilities

Disadvantages

- Does not secure two pieces of plywood together
- Difficult to get smooth even motion

Using a Universal Joint

Advantages

- Very good range of motion
- Ease of mounting

Disadvantages

- Not able to support a large enough load
- Not a very low profile
- Will require some fabrication for mounting

Using a Ball Joint

Advantages

- Good range of motion
- Easy of mounting
- Has good load bearing capabilities

Disadvantage

- Can be expensive
- Will require some fabrication for mounting

Method of Powering:

For our initial design we have decided to use two AC sources. One source will be used to power the motors, while the other source will be used to power the microprocessor. Depending on time constraints, we may add the option of being able to use both batteries and AC power sources. This way, a user will be able to easily travel with the telescope stand and use it outside for a decent period of time, but save on the cost of batteries by being able to plug it in for power when an outlet is available.

Wall outlet (Dual AC Sources)

Advantages

- PIC board ready
- No limit to available power
- Never have to replace batteries
- Very reliable
- Cheap

Disadvantages

- Dangerous high voltage
- Not very portable
- Restrictions on outside use
- Cords can trip people

Battery power

Advantages:

- Portable
- Less restrictions on outdoor use
- No cord to trip over

Disadvantages:

- Limited supply of power
- Design must be based on complete efficiency to maximize battery life
- Batteries must be replaced or recharged
- Batteries are more expensive than AC

Building Material

There are not many different choices available for building material. The logical choice would be to create the platform out of wood like the one designed by a past senior design group. The other option that we considered would be out of metal, ideally aluminum because of its light weight. The main reason we decided not to use the metal platform is because of the difficulty of fabrication and special tools required. We decided to build the platform from wood because of its ease of fabrication and it is more aesthetically pleasing.

Building an Aluminum platform

Advantages

- Strength
- Rigidity

Disadvantages

- Difficult to fabricate
- Not as aesthetically pleasing
- Weight

Building a Wood platform

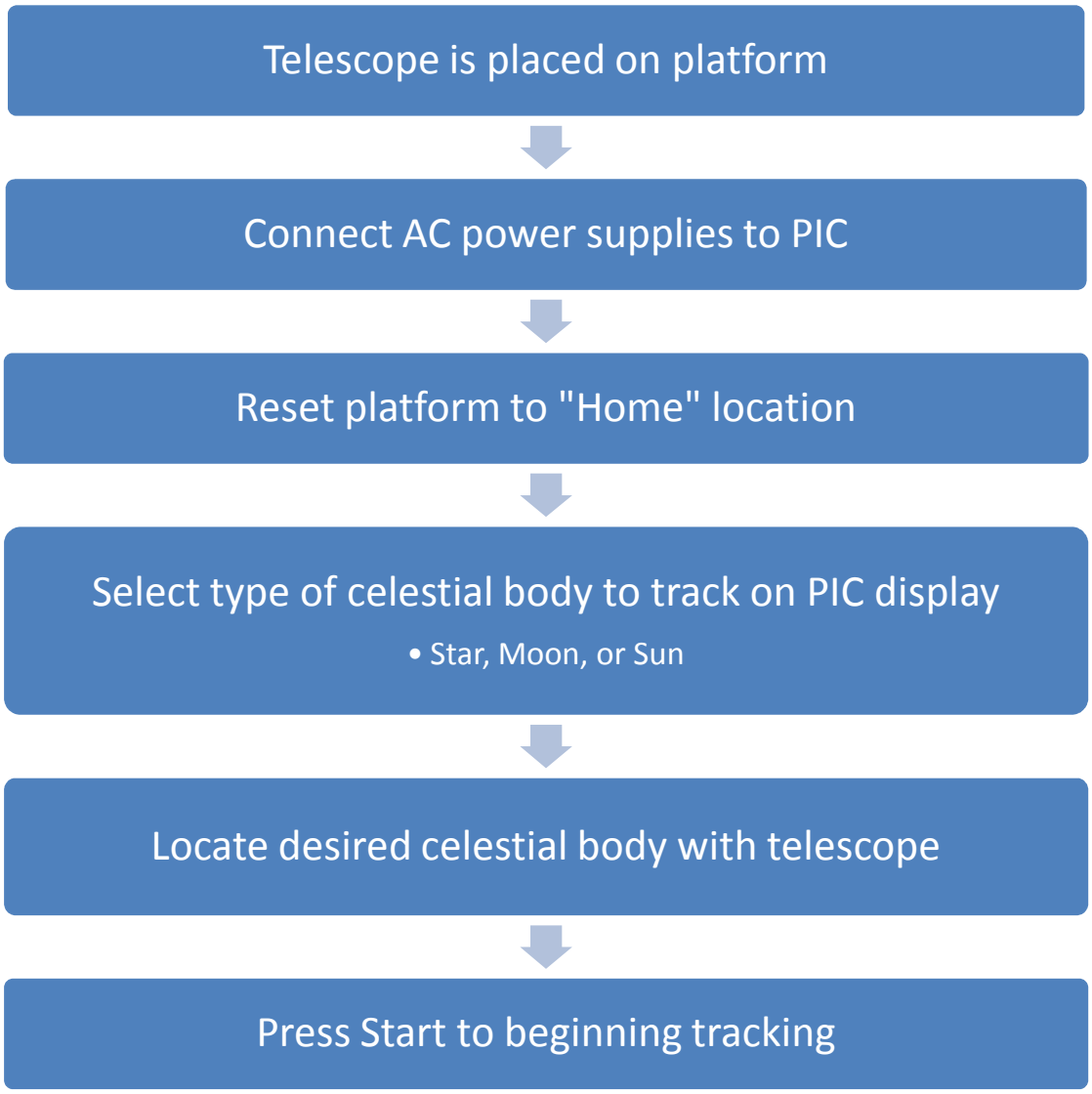
Advantages

- Easy to fabricate and modify
- Strength
- Rigidity
- More lightweight than metal

Disadvantages

- Still fairly heavy

Process


Telescope is placed on platform
Connect AC power supplies to PIC
Reset platform to "Home" location
Select type of celestial body to track on PIC display
• Star, Moon, or Sun
Locate desired celestial body with telescope
Press Start to beginning tracking

Budget:

Part/Description	Quantity	Retail Cost	Expected Cost	Total Cost	Notes
Ball Joint	1	$30	$30	$30	
4’ x 8’ x 3/4” Plywood	1	$20	$20	$20	
Linear Actuator – Stepper Motor	2	$500	$0	$0	Dr. Glower supplied
Rotational Actuator – Stepper Motor	1	$20	$0	$0	Dr. Glower supplied
PIC Board	2	$30	$30	$60	
Hardware	1	$5-15	$10	$10	Ex: Screws, bolts, brackets
			Total:	$120	

Summary:

This document shows that there are several options when designing any device, and that we have considered all the options for our specific application. By the end of the semester, we will have a working prototype that will follow the sun, moon and stars to allow an astronomer to follow and photograph celestial bodies. Our platform will consume less power than the platform designed by the previous group, be larger to accommodate an 18” telescope and be more aesthetically pleasing.

Our client, Dr. Glower, hopes to publish a paper on the equatorial platform and have it for his own use.